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Shale gas impacts on groundwater resources: Understanding the behavior of a shallow aquifer around a fracking site in Poland

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Abstract

Exploitation of shale gas by hydraulic fracturing (fracking) is highly controversial and concerns have been raised regarding induced risks from this technique. As part of the EU-funded SHEER Project, a shallow aquifer used for drinking water, overlying a zone of active shale-gas fracking, has been monitored for more than a year. Early results reveal the functioning of the shallow aquifer and hydrochemistry, focusing on the identification of potential impacts from the shale gas operation. This stage is an essential precursor to modeling impact scenarios of contamination and to predict changes in the aquifer.

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Keywords: shale gas; environmental impacts; monitoring; Quaternary aquifer

1. Introduction

Exploitation of shale gas by hydraulic fracturing ('fracking') gained its controversial status after many well owners in the USA, whose wells were in the vicinity of shale gas pads, complained about changes in the quality of their drinking water. For example, studies by Jackson et al. [1] and Darrah et al. [2] suggest that some wells have been contaminated by stray gases, likely due to poor well construction. This followed exemption of shale gas

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developments from much of the pre-existing environmental regulation in the USA [3]. Reports of such problems in the USA triggered public opposition in Europe at the time the first drilling permits were being awarded. As a consequence, a cautious approach is taken in Europe compared to the USA. Several potential impact types have been identified [3] and the need for baseline monitoring prior to any shale gas activity (which is missing in US regulation) has been widely acknowledged by the scientific community [4]. In Europe, Poland is the leader in shale gas exploration and exploitation, as one of the European countries with the largest estimated reserves, and twenty-seven horizontal wells have been hydraulically stimulated since 2010 [5]. Exploration for shale gas resources is generally well perceived in Poland and shows a strong acceptance by the population.

As part of the European approach, the SHEER (SHale gas Exploration and Exploitation induced Risks) Project is one of a small number of research projects investigating shale gas risks, funded by the EU Horizon 2020 program. It aims to develop best practice in order to understand, prevent and mitigate the potential short- and long-term environmental impacts and risks from shale gas exploration and exploitation. Within the SHEER project, three major potential risk areas have been identified: induced seismicity, groundwater contamination and air pollution.

Here, the focus is on understanding the groundwater contamination risks. Although much controversy has centered on the hypothesis that fracking (which is invariably at great depth) might create direct contaminant pathways with upward-oriented hydraulic gradients, previous studies have demonstrated that this is extremely unlikely [6]. Far more likely is pollution from surface or near-surface operations, involving transmission of gas or handling of co-produced waters. To interrogate these issues, a study has been carried out into a Quaternary aquifer, which provides drinking water in the study area and on which a drilling pad of recently-drilled and fracked shale gas wells is located. This shallow aquifer has already been monitored for more than one year, and information regarding the functioning of this aquifer can be extracted from the monitoring data. Thoughts regarding the monitoring of impacts of shale gas exploration on groundwater resources are also included in the discussion.

2. Description of the study area

The drilling pad is located in the Stara Kiszewa concession, about 40 km from the city of Gdańsk, in the Pomerania region, Northern Poland (Fig. 1). The region forms part of the Baltic Basin and has a simple geological structure which is relatively tectonically undeformed.

2.1. Geological and hydrogeological setting of the drilling site

Prior to commencement of any shale gas drilling operations, the drilling pad was constructed with impermeable liners and bunded drainage capture with the purpose of preventing any leakage of fluids at surface (from drilling, fracking or flowback of deep well fluids). The drilling pad hosts three boreholes drilled to a depth of about 4 km (Fig. 2). The vertical borehole (Wysin-1) was drilled in 2013 to prove the stratigraphic sequence. Subsequently two deviated boreholes (with 1 km laterals at depth) were drilled in autumn 2015 (Wysin-2H and Wysin-3H trending ESE and WNW respectively). The horizontal laterals of these boreholes are aligned roughly parallel to the general fault trend in the region (NW-SE faults; [7]) although faulting in the Lower Palaeozoic strata is rather limited [8,9].

The vertical borehole Wysin-1 reaches Middle Cambrian deposits (54.5 m thick; [10]), which consist of black mudstones and clays interbedded with fine-grained quartz sandstones. The horizontal borehole Wysin-3H is drilled into Ordovician marls, claystones and shales belonging to the Prabuty Formation. This layer is relatively thin (~30 m thick). The other horizontal borehole (Wysin-2H) is drilled into Silurian shales, in the lower part of the succession (Wenlock Formation), which are almost 2 km in thickness. The Silurian shales are covered by about 400 m of Permian rocks, which include the Zechstein Formation. The Zechstein, consisting primarily of anhydrite and halite deposits, is effectively impermeable and acts as a sealing layer - as it does for many North Sea oil and gas reservoirs. It is followed by 600 m of Triassic strata, including Buntsandstein claystone-mudstones and Muschelkalk marls and dolomites with limestone intercalations and claystones. These are overlain by 300 m of Jurassic deposits. Cretaceous sediments (600 m thick) lie discordantly on the Jurassic: Lower Cretaceous sands and mudstones and Upper Cretaceous glauconitic sandstones, marly limestones and marls [7]. Finally, the sequence is completed by 100 m of Tertiary sediments from the Miocene (carbonaceous silty clays interbedded with sandy silts) and 100-150 m of Quaternary sediments resulting principally from the last glaciations.